the highest was 93°, at Fort Simcoe on the 28th, and the lowest, 20°, at Cascade Tunnel on the 3d. This was the coolest May on record. The average precipitation was 3.21, or 0.62 above normal; the greatest monthly amount 7.74, occurred at Ashford, and the least, 0.53, at Kennewick.

West Virginia.—The mean temperature was 68.1°, or about 6.0° above normal; the highest was 95°, at Point Pleasant on the 10th and at Spencer on the 11th, and the lowest, 33°, at Beckly (Raleigh) on the 4th. This was the warmest May on record. The average precipitation was 3.01, or about 0.75 below normal; the greatest monthly amount, 5.92, occurred at Fairmont, and the least, 0.65, at Beckly.

Wisconsin.—The mean temperature was 62.9°, or about 6.0° above normal; the highest was 93°, at Butternut and Prairie du Chien on the 6th, and the lowest, 29°, at Florence on the 20th. Heavy frosts occurred at several northern stations on the 31st. The average precipitation was 5.00, being slightly below normal in the southeastern counties and much above normal in the Grand River Valley; the greatest monthly amount, 9.35, occurred at West Bend, and the least, 2.44, at Delevan.

SPECIAL CONTRIBUTIONS.

RECENT PUBLICATIONS.

By Dr. J. H. McCARTY, Librarian Weather Bureau.

Austria.—Hungary. Die Luftwiderstands-Gesetze; der Fall durch die Luft und der Vogelflug. Mathematisch-Mechanische Klaerung auf experimenteller Grundlage entwickelt von Friedrich Ritter von Loessl, ober Engenieur. 8vo. 304 pp. Wien. 1896.

France.—Annales de l'Observatoire Royal de Belgique. Observations Meteorologique D'Uccle 1894. 4to. 40 pp. Bruxelles. 1896.

British Empire.—Australia. The Abercromby Essays, on the Australian Weather. Three Essays by H. C. Russel and Henry A. Hunt. 101 pp. and 4 plates. Sydney. 1896.

British Empire.—England. Reduction of Greenwich Meteorological Observations. Part III. Temperature of the Air as determined from the observations and records of the fifty years, 1841 to 1890, made at the Royal Observatory, Greenwich, now directed and discussed under the direction of W. H. M. Christie, M. A., F. R. S., Astronomer Royal. Fol. 119 pp. 1 plate 12 by 16. London. 1895.

British Empire.—Dominion of Canada—New Brunswick. Department of Public Works, St. John, N. B. Sewerage and Water Supply. Engineer and Superintendent's Report, 1895. 8vo. 88 pp. St. John, N. B. 1896.

British Empire—Scotland. The Sixty-third Annual Report of the Royal Cornwall Polytechnic Society, 1895. Falmouth. 1896. 163 pp.

France.—Travaux et Memoires du Bureau International des Poids et Measures. Publiés sous les Auspices du Comitè International par le Directeur du Bureau. Tome XI. 4to. 403 pp., with 2 steel engravings 10 by 12. Paris. 1895.

Germany.—Der Vogelflug, als Grundlage der Fliegekunst von Otto Lilienthal. 8vo. 187 pp. 1 frontispiece, 8 diagrams, 80 woodcuts. Berlin. 1889.

Germany.—Hygienische Meteorologie für Aerzte und Naturforscher, von Dr. W. J. van Bebber, mit 42 in den Text gedruckten Abbildungen. 8vo. 330 pp. Stuttgart. 1895.

Germany.—Die Fortschritte der Physik, im Jahre 1890. Dargestellt von der Physikalischen Gesellschaft zu Berlin. 46. Jahrgang. 1. Abtheilung, enthaltend: Physik der Materie. Redigirt von Richard Börnstein. Braunschweig. 1896. 8vo. 523 pp.

Germany.—Deutsches Meteorologisches Jahrbuch für 1895. Freie Hansastadt Bremen. Ergebnisse der Meteorologischen Beobachtungen im Jahre 1895, und in dem Lustrum 1891-1895. Herausgegeben von Dr. Paul Bergholz. Jahrgang VI. Mit 8 Tafeln. 4to. 127 pp. 8 plates. Bremen. 1896.

Germany.—Königlich Preussisches Meteorologisches Institut. Das Meteorologische Observatorium auf dem "Brocken" zur Feier der Einweihung am 31 May, '96. 4to. 1 plate 41 pp. Berlin. 1896.

Greece.—Observatoire. National D'Athenes. Section Gèodynamique. Bulletin Mensuel Seismologique. 1, annèe 1896. No. 1, Janvier; 2, Fevrier; 3, Mars; 4, Avril. 4to. 4 pp. Athens. 1896.

Japan.—Annual Report Central Meteorological Observatory for the year 1894. Pt. 1. Met. Observations in Japan. Tokio (1895). 4to. 201 pp. Chart.

Russia.—Report of the Imperial Russian Geographical Society, for 1895. 8vo. 191 pp. St. Petersburg. 1896.

Russia.—(In the Polish language.) Meteorological Bulletin, 1st part, for the year 1893. 4to. 76 pp. Warsaw. 1895.

Russia.—(In the Polish language.) Meteorological Bulletin, 2d part, for the year 1893. 4to. 79 pp. Warsaw. 1895.

United States of America.—Proceedings of the American Association for the Advancement of Science, 44th meeting, held at Springfield, Mass., August-September, 1895. 8vo. 414 pp. Salem, 1896.

United States of America.—Proceedings of the Rochester Academy of Science. Vol. III. 8vo. 150 pp. 2 maps. Rochester, N. Y. 1896.

United States of America.—Annals of the Astronomical Observatory of Harvard College. Vol. XXX, Part III, 1 pl. 268 pp. Cambridge, Mass. 1895.

United States of America.—Tenth Annual Report of the Commissioner of Labor, 1894. Strikes and Lockouts. Vol. I. Analysis of tables. General tables of strikes and lockouts. Washington, D. C., 1896. 8vo. 1373 pp.

United States of America.—Annual report of the Iowa Weather and Crop Service for the year 1895. John R. Sage, Director. Geo. M. Chappel, M. D., Local Forecast Official, U. S. Weather Bureau, Assistant Director. 8vo. 81 pp. 22 woodcuts. Des Moines. 1896.

United States of America.—Annals of the New York Academy of Science, late Lyceum of Natural History. Vol. IX. Nos. 1-3. 8vo. 180 pp. XVI plates. New York. 1896.

United States of America.—Hydrographic Office Report. No. 64. Vol. II. 3d ed. 8vo. 489 pp. 1 map 12x24.
The Navigation of the Gulf of Mexico and Caribbean Sea.
The Coast of Mainland from Key West, Fla., U. S., to the Orinoco River, Venezuela, with the adjacent islands, Cays and Banks. Washington, D. C. 1896.

United States of America.—Washington Observations, 1894. Appendix 1.
Magnetic Observations at U. S. Naval Observatory, 1894. By Lieut. C. C. Marsh, U. S. Navy. Capt. F. V. McNair, U. S. Navy, Superintendent. Washington, 1895. 113 pp. 4to. 13 plates.

United States of America.—U. S. Department of Agriculture, Weather Bureau. Climate and Crop Service. Texas Section. Special Bulletin No. 8. Report on Tornadoes of May 12 and 15, 1896, in Northern Texas. Isaac M. Cline, M. D., Local Forecast Official. Pp. 3. 2 plts. 8v. Galveston. 1896.

THE DESTRUCTIVE FORCES OF HURRICANES AND THE CONDITIONS OF SAFETY AND DANGER.

Extracts from communication by GEN. E. P. ALEXANDER, of Georgetown, S. C. (dated May 29, 1896).

It is the purport of this article to set forth some of the practical conclusions and results of a study of the destructive forces of the tropical hurricanes which sometimes assail our Atlantic and Gulf coasts in the months of August, September, and October. The study was suggested by personal experiences and observations on several occasions, but more particularly in the storm of August 27, 1893, which destroyed over 2,000 lives and perhaps $1,000,000 worth of property. Newspapers and magazines for months afterward teemed with accounts of the havoc wrought, and of the noble charities for the relief of the desolated communities to which the occasion gave rise. But the popular ideas of the dangerous forces of the hurricane as given by the published accounts are exceedingly vague and indefinite, exaggerated in some respects, and underestimated in others. One magazine, for instance, stated that many persons were killed by "sheer pressure and fury of the wind, not a bruise being found on their bodies." Such a statement is merely absurd. But to the ignorant it suggests mysterious and universal destruction, against which no precautions are of any avail.

In every hurricane there are many individuals who escape and many structures that withstand it. An intelligent study of the conditions surrounding these individuals and buildings will give us a fair measure of the force of the wind and waves and will suggest the most effective means of protection. Briefly, it may be said that the dangerous elements are so limited and precautionary measures are so simple and easy, that it is only through negligence that lives are lost on land and dwellings destroyed.

The hurricane of the Atlantic and the typhoon of the Pacific must be sharply distinguished from the tornado that occurs on land, not only in America, but also in Europe, Africa, and India. Atlantic hurricanes are generated in the region where the northeast trade winds die out as they approach the belt of the equatorial calms. They reach the Atlantic or Gulf States principally between July and October. The most violent winds whirl around a central region of low barometric pressure which is in the midst of a much larger area of cloud and rain. The whirl is always in the same direction, viz, such as to carry an object from the north side of the central region around by the west to the south, and thence around by the east to the north side again. This circulation is technically spoken of as a negative rotation, or one that is contrary to the direction of motion of the hands of a watch. As the winds on the south side of such a hurricane blow eastward, this circulation is also spoken of as being against the sun, since the sun appears to move from the east by the south toward the west. The maximum velocity of the hurricane wind has been known to exceed the rate of 120 miles per hour, but this is only in puffs of a few seconds' duration, as the total movement of the wind for a whole hour rarely exceeds 60 miles. Now, wind pressure is usually estimated at 2 pounds per square foot of surface when blowing perpendicularly to that surface with a velocity of 20 miles per hour; 8 pounds for 40 miles, and 18 pounds for 60 miles, the pressure increasing as the square of velocity.

If we assume the highest velocities and calculate the pressures by this rule, we would expect few ordinary houses to resist them. But, in the wake of a storm, a study of the structures which fail and of those which resist is generally calculated to surprise an observer far more by the apparently weak ones which have resisted the winds than by the apparently substantial ones which have failed. And when those which have failed are examined, it will be found, almost invariably, that failures are due to unstable foundations or to lightly attached roofs. In fact, it may be taken as a measure of the force of hurricane winds that the frame of any ordinarily good house will resist them. But the foundations must be firm and the roofs fairly well framed and attached. In new houses, by the use of wooden ceiling instead of plastering, and a few angle irons and bolts, one can easily have a structure, like a double box, which could be almost rolled over without injury. Old houses, badly constructed and with poor foundations, may be easily preserved by a few stout braces or inclined props on sides opposite the wind. In short, the wind of a cyclone by itself seldom works serious injury. It is only where it has the water as an ally and accumulator of its forces that its ravages are great. When a hurricane passes inland, it soon becomes little more than a bit of very bad weather. Its great instrument of destruction is the so-called tidal wave or storm tide, or, more properly, storm wave, which is raised by it and which submerges the low lands of the coast. Below the limit to which these waves rise is the zone of danger in a hurricane; above it is the zone of easily attained safety.

How far this danger line may extend above ordinary high water depends so largely upon local configuration of coasts that it is only to be determined for any locality by observation. Unfortunately, reliable measurements and data upon this point are rare and difficult to obtain. Popular accounts are always exaggerated, being largely based upon the action of surface billows, which send water and drift far above the general level of the storm wave. A vessel, for instance, drawing 8 feet, may be carried by successive billows across a marsh submerged only 4 feet beneath the general level. I have read accounts of combined storm waves and high tides rising 10 or 12 feet above ordinary high water mark, but when the action of billows is eliminated and careful measurements are made, the highest record of a storm tide above ordinary high water which I have been able to find anywhere is 8.2 feet. This limit was reached at Fort Pulaski, Ga., in the great gale of August 27, 1893, which broke all records in the height of its waters, in the destruction of life and property, and in the measured velocity of its winds, which at Charleston for a few moments exceeded 120 miles per hour. As this gale is one of great interest, the reader is referred to the records published in the MONTHLY WEATHER REVIEW for October, 1893, page 297. The center of the hurricane passed directly over Savannah, and it will be seen that there the barometer fell lowest and the storm tide rose highest, the wind falling to a dead calm for twenty minutes as the center passed, after which it rose from the opposite quarter. The center passed about 80 miles west of Charleston. The accompanying diagram (Fig. 1) shows the phenomena of this date.

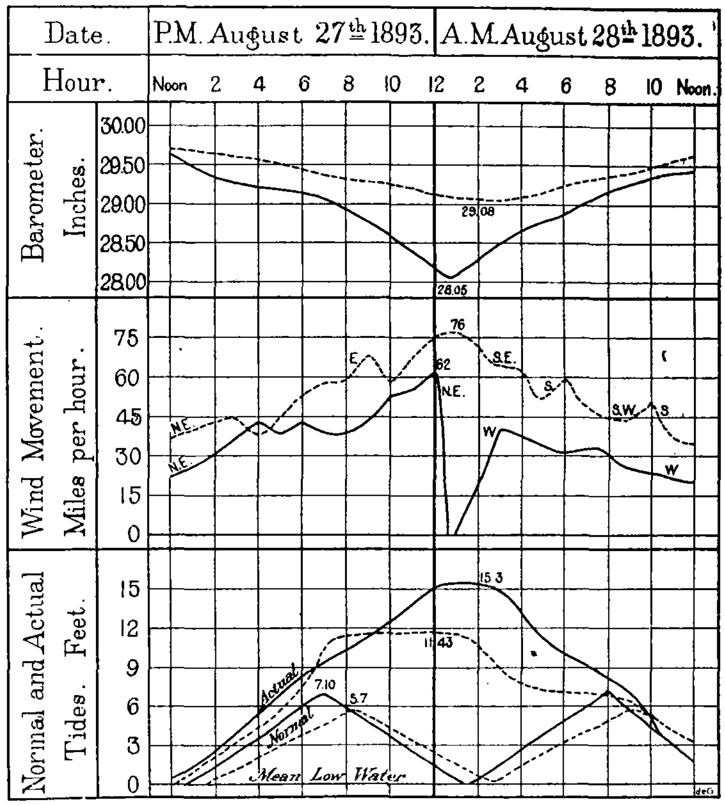

FIG. 1.—Barometer reading and movement of wind and tides at Charleston, S. C., and Savannah, Ga. Dotted lines show Charleston records and solid lines show Savannah records.

The following table shows the rise of the tide caused by this hurricane, and for comparison, also the highest storm tides ever recorded at several Atlantic, Gulf, and Lake ports, as shown by records of the U. S. Coast Survey and Engineer offices.

Highest storm tides at various points.

Locality.	Date.	Height of tide.	Moon's age.
Boston, Mass	April 16, 1851	5.3	15
Sandyhook, N. J	Sept. 10, 1889	3.9	14
Fort Monroe, Va	Mar. 10, 1846	5.1	12
South Island, S. C	Oct. 13, 1893	6.8	2
Fort Sumter, S. C	Aug. 27, 1893	6.4	14
Fort Pulaski, Ga	Aug. 27, 1893	8.2	14
Mobile, Ala	Oct. 2, 1893	7.0	20
Buffalo, N. Y	Jan. 9, 1889	8.0	6
Duluth, Minn	Sept. 28, 1895	4.0	9

The plane of reference is ordinary high water, and the age of the moon is given in each case to indicate whether the storm tide coincided with the normal high tides, which occur at all the Atlantic ports about each full or new moon. There is no tide at Lake ports, and but little in the Gulf.

From the above we see that the serious ravages are committed by the water rather than by the wind, and that they are confined to a narrow zone seldom, if ever, reaching more than 8 or 9 feet above the plane of ordinary high water. Above that zone ordinary well built houses will easily resist the winds if the house and the roof are securely framed together and the foundations are stable. If there are weak points, even cheap and ordinary props or braces, which can be improvised rapidly, are very effective in breaking up vibrations and resisting the pushes and shakes of the wind. Within the zone of danger from water, the dash of the waves and the tendency of the water to lift and float all wooden structures must be provided for. The limits of this article do not permit a full discussion of the magnitudes of these dangers and the various means by which they may be met, but it may be said briefly that pile foundations, or the equivalent, posts framed into buried timbers, are at once cheap and efficient.

A very instructive illustration is shown in some photographs of Krantz's cottages at Grand Isle, Barataria Bay, La., before and after the hurricane of October 2, 1893, in which over a thousand lives were lost on the coast of Louisiana. [This hurricane did not affect the South Carolina coast as seriously as the following one of October, 13, 1893.] These photographs show that the cottages were not materially damaged by the wind, scarcely even a blind was torn off, but they were simply floated off their low brick foundations and drifted up together. Had they been raised a few feet upon piles, or even on substantial brick pillars and bolted to them, slight injury would have been done and no lives lost.

In Georgetown County, S. C., after the great gale of 1822, in which 200 lives were lost, the rice planters on two exposed islands built brick storm towers, large enough to shelter all their slaves, which towers are still intact. Others built storm proof cabins and storm proof rooms adjoining their summer houses on the beaches, some of which, still standing in 1893, preserved the lives of their occupants while their neighbors were drowned.

FIG. 2.—Storm-proof cabin of 1822.

Within the danger zone stables should always have an elevated floor or platform, with an inclined plane by which stock can reach it. A few barrels of fresh water stored away at the approach of a gale, and covered against salt spray, will often prove a great boon to both man and beast. At isolated camps and fields where individuals may be suddenly surprised, a safe refuge may be quickly made in a tree by cutting off the top and limbs to diminish the danger of its being blown over, and fixing a seat and lashings and means of ascent. Where there is no secure refuge above the reach of water a boat or raft should always be prepared beforehand, and retreat should be made while the winds are blowing on shore.

The above suggestions are enough to indicate not only how easily intelligent foresight can protect life and property, but also how extremely valuable are timely warnings to those living in the danger zone when a hurricane is coming. No matter what precautions have been taken beforehand, it is worth while to overhaul everything. When harvesting is going on and men, animals, vehicles, and boats are scattered far and wide, cutting, curing, and handling the crops, every possible hour of warning is of great value.

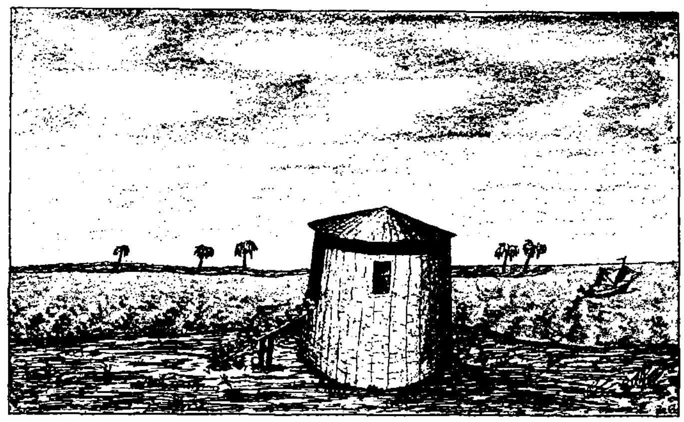

FIG. 3.—Storm-proof tower of 1822.

The sky and clouds give their own warnings of the approach of a hurricane, but the trouble about these is that the sky gives so many false alarms. It is easier for the Weather Bureau to give ample warning of an approaching hurricane. At its birth in the doldrums the storm has a moderate drift to the westward. It gradually turns slowly northward. After it leaves the tropics it gradually moves in a northeast direction. But from our picket stations in the West Indies our Weather Bureau can be promptly notified of its birth and movements long before it can make an assault upon our shores, should it head in our direction. If the warnings of the Weather Bureau, therefore, are promptly transmitted to the communities which are exposed along the seacoast, these can interpret the daily aspects of their own skies with some confidence, and need never lose work by taking false alarm, or be taken unawares by real danger.

Until recently the warnings given by the Weather Bureau were confined to the display of danger signals at the ports and towns along the coast. A great advance has been made by the employment of special boats and launches, which, upon occasion, are sent to carry messages to isolated places. But a still further advance is practicable, and should be carried out by combined official and private enterprise. The present system might be supplemented by branch lines of sound signals, such as the firing of guns,[1] or the explosion of some cheap form of bomb, by which warnings may be quickly conveyed to the laborers in the most distant fields, the fishermen on the farthest banks, and the occupants of the most isolated cabins. These are the people whose lives and property are oftenest lost for the lack of warning.

[1] On account of the numerous accidents incident to the careless use of cannon, bombs, and explosives, it has therefore been deemed wisest to rely upon the telegraph, telephone, flags, and other visual signals.—[C. A.]

To give some idea of the frequency of tropical hurricanes a table is attached giving dates of all that have occurred on the coast of South Carolina for two centuries.

Hurricanes on the coast of South Carolina.

Year.	Month.	Day.	Lives lost.	Moon's age.
1700	Sept	16		1
1713	..do	16		25
1728	..do	14		8
1752	..do	15	20	5
1787	..do		23	
1797	..do	5		12
1804	..do	7		1
1811	..do	10		22
1813	Aug	27	15	0
1815	Sept	28		25
1822	..do	27	200	10
1830	Aug	16		27
1837	Sept	1		0
1841	..do	16		29
1844	Oct			
1846	Aug	16		23
1850	..do	24		16
1851	..do	24		27
1852	..do	27		11
1854	Sept	7		14
1871	Aug	19		3
1874	Sept	28	2	16
1878	..do	11		13
1881	Aug	27		3
1882	Oct	11		29
1885	Aug	25	21	14
1893	..do	27	2,000	14
1893	Oct	13	25	2
1894	Sept	27		27

The above table gives the dates of all tropical hurricanes that have visited the coast of South Carolina during the last two centuries of which record can be found. Where loss of life on land is mentioned, the estimated number is given. The moon's age at each date is also shown, to indicate whether the hurricane occurred nearest the time of spring or neap tides. Of 29 in all, 16 fell nearest to the spring tides, and 11 the neap.

REPORT ON THE TORNADOES OF MAY 25 IN THE STATE OF MICHIGAN.

By NORMAN B. CONGER, Inspector, Weather Bureau (dated Detroit, June 22, 1896).

The data for this report is gathered from all reliable, available sources, but the most reliable data is contained in the report of the committee on cyclone damages appointed by Governor John T. Rich to ascertain the total damages and the amount of relief necessary in the district covered by the tornado. The report of this committee covers the counties of Oakland and Lapeer only, and it is in this district that the majority of the damage occurred, and where the tornado was most severe. That report covers the path of the storm so fully that it will not be necessary to repeat it. Reports were also received from the postmasters at Dryden, Utica, Amadore, Fostoria, Otisville, Oakwood, Ortonville, Otterlake, Metamora, Thomas, and one by Mr. Alexander G. Burns, of this office, who made personal inspection of the track of the storm that passed over Walkerville, Canada, just across the river from Detroit.

I made a personal visit the day after the storm to Thomas (Oakland County) to observe the action of the tornado and to follow its path for a short distance and observe its characteristics. The greatest damages were observed at Ortonville, Oakwood, and Thomas, in the northeast corner of the county.

I have made a careful study of the path of the storm at Thomas, Oakland County, and inclose a sketch, Chart No. VIII, drawn by Mr. E. F. Hulbert, showing the manner in which the storm distributed the debris.

The path of the storm was distinctly marked at Thomas. The south side of the storm showed all the trees, houses, and fences thrown to the northeast, while in the center of the path, which was probably an eighth of a mile in width at this point, the debris was laid to the east. The fence rails were laid due east and west, and all were laid out as carefully as though placed there by the hand of man. No two rails were laid one on another. On the north side, where the distinct path was of the same width as the center, the houses and debris were all turned to the south or southwest, with some few pieces lying to the west. From conversation with those who had visited the whole district, I learned that the same characteristics were observed throughout the length of the path. It was noticed in the center of the path that the grass was pounded down into the earth as though it had been washed into the earth by a heavy flow of water. The small trees on the south side of the path were stripped of their bark, even to the twigs, as though done by the careful hand of an experienced artisan. On one side of the road which runs north, at Thomas, the house of Mr. Kidder was carried bodily for about 300 feet, and then smashed into the earth, the contents of the house scattered beyond finding, while across the road, some 600 feet to the north, the frame house of Mr. Copland was taken free from the stone foundation, and the debris were found from 2 to 10 miles farther east-northeast. All that was left of his house was a square piano, which was standing on its side some 200 feet directly north of the foundations of the house, one end being pounded full of grass. One peculiarity of the freaks of this storm was the unroofing of the post office at Thomas, leaving only the lower story standing, and in the window was still displayed the weather forecast card of the day: "Severe local thunderstorms this afternoon and to-night; showers followed by fair, Tuesday." The forecast had been terribly fulfilled in this section.

Tornadoes occurred, or windstorms were reported, at about 6 p. m., local time, and at about 20 localities in the following counties, as represented on the map: Montcalm, Kalkaska, Midland, Bay, Tuscola, Genesee, Lapeer, Oakland, Macomb, St. Clair, Sanilac, and Wayne, the most damage occurring in the counties of Oakland, Lapeer, and Genesee, in the order named. That in Kalkaska County simply cut a path through the woods, and did not touch any houses.

The report of the damages from the storm at Mr. Clemens', Macomb County, has not been received, but the storm was quite severe there, and 2 lives were lost.

The reports from all sources indicate that there were 45 lives lost, about 100 persons injured more or less severely, and about $400,000 in damages to houses, barns, etc. The report of the committee gives also the amount of damage to crops, orchards, and fences in Lapeer and Oakland counties only.

KITE EXPERIMENTS AT THE WEATHER BUREAU.

By C. F. MARVIN, Professor of Meteorology, U. S. Weather Bureau.

[Continued from April REVIEW.]

IN the April REVIEW the manner of using steel wire for the kite line was described and the results of experiments given, showing the strength and the best arrangement of the wire, splices, string, and other members composing the kite line. The means employed for determining accurately the length of wire unwound from the reel in any case were also given. We will next consider the action of the forces on kites and the form and construction of those with which experiments were made at the Weather Bureau.

General remarks on single plane and cellular kites.—Before the writer began work upon the kite problem many efforts had been made to reach great elevations with kites of the Malay type, the construction of which has already been described. It was often found that these kites would not continue to behave properly hour after hour. When several kites were flying in tandem they would fly very nicely for a time, but a strong gust of wind or the continued action of moderate winds would cause some derangement in one or more of the kites. This would mar the success of the experiment, if it did not bring about some worse result. The real cause of such difficulties was not fully understood at that